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(54) **BASE STATION ANTENNA ARRANGEMENT, BASE STATION ANTENNA AND ANTENNA ASSEMBLY FOR BASE STATION ANTENNA**

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H01Q 1/36 (2006.01)
H01Q 19/10 (2006.01)

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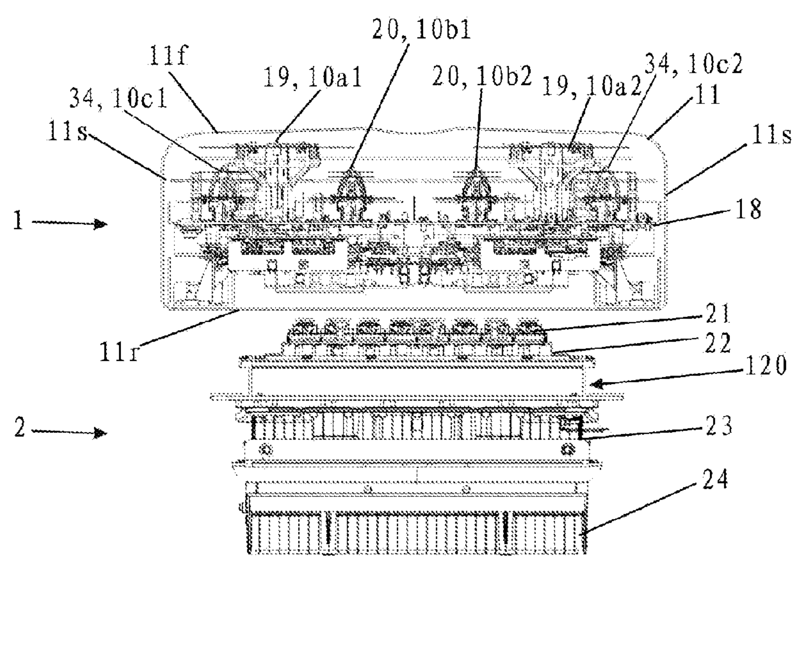
(57) **ABSTRACT**

The present application relates to an antenna assembly for a base station antenna, a base station antenna arrangement and a base station antenna. The antenna assembly has a reflector, which has a longitudinal extent, a front side and a rear side opposite the front side, where the front side is configured for radiating elements to be arranged thereon, wherein, the reflector has a first longitudinal section residing in a first plane and a second longitudinal section residing in a second plane that is adjacent to the first longitudinal section, where the first plane is rearward of the second plane. The properties of the base station antenna arrangement and the base station antenna may be improved through the antenna assembly.

21 Claims, 6 Drawing Sheets



(58) **Field of Classification Search**
CPC H01Q 1/427; H01Q 1/42; H01Q 1/405; H01Q 1/246
See application file for complete search history.

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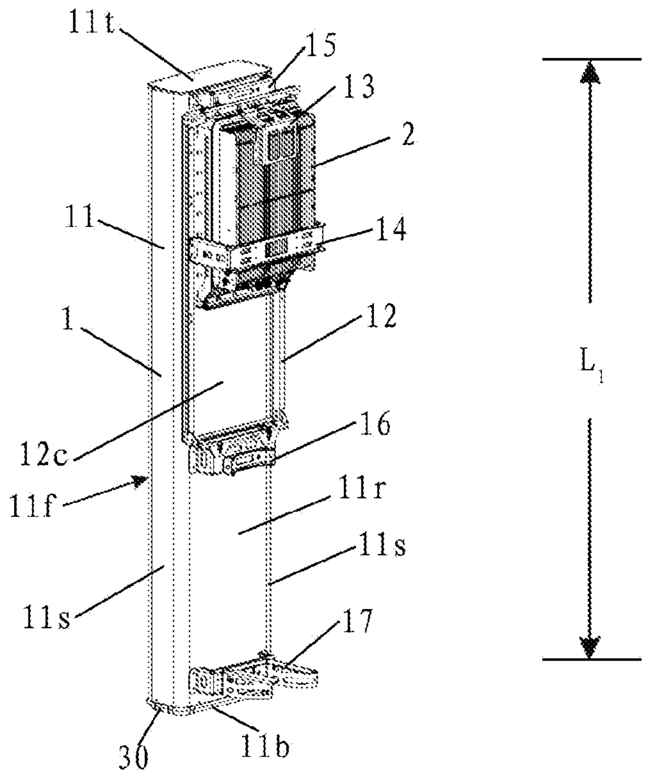
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Fig. 1

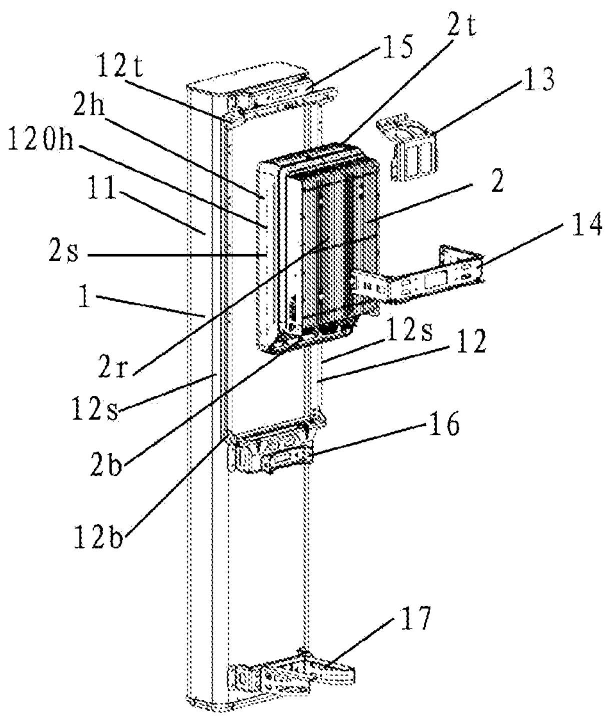
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Fig. 2

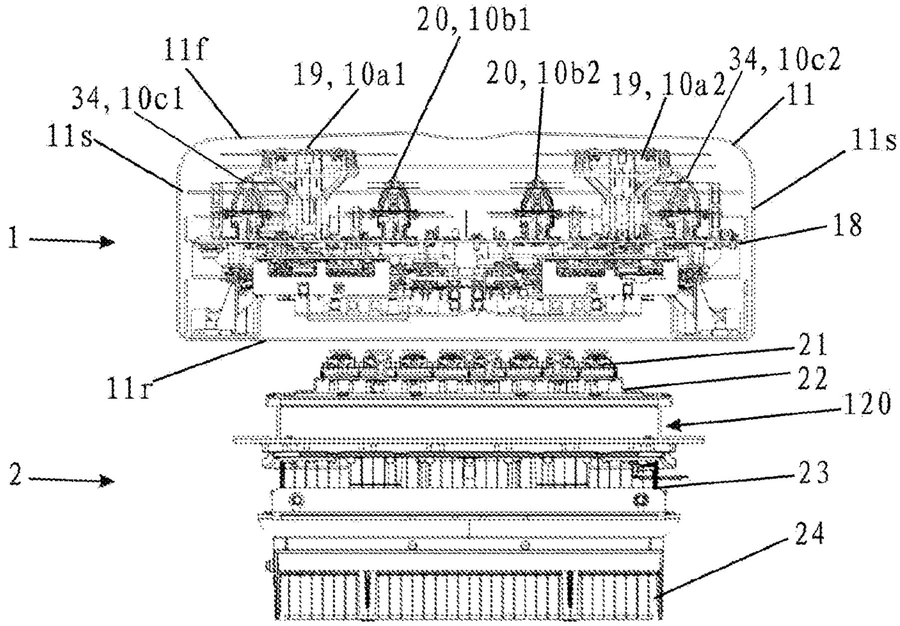

Fig. 3

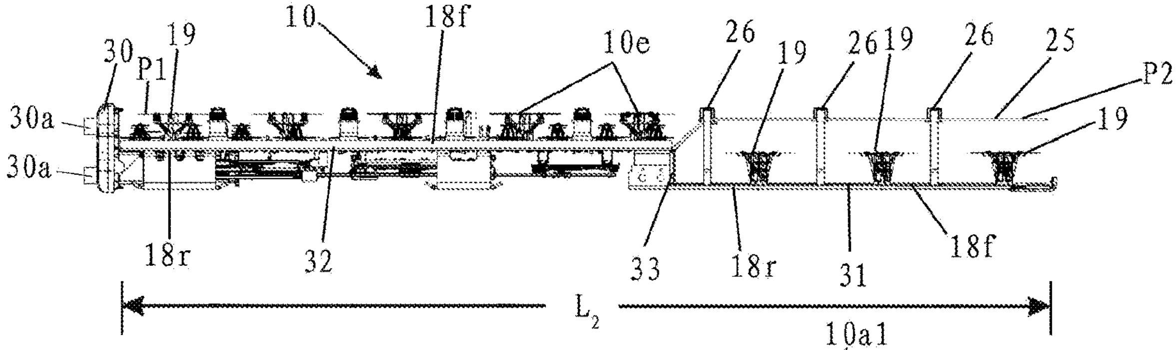

Fig. 4

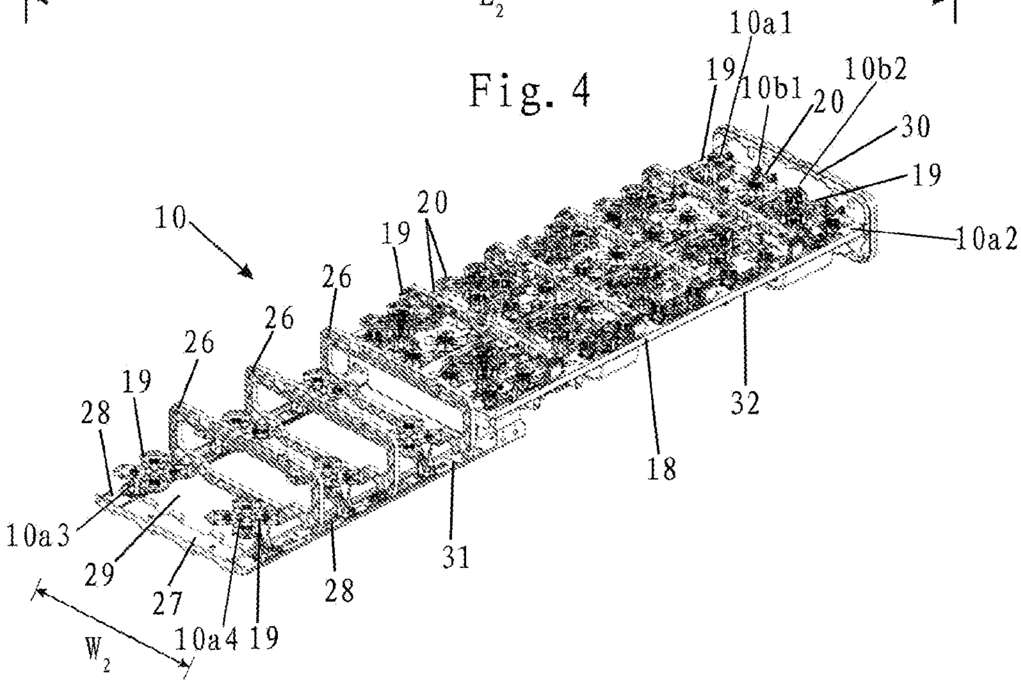

Fig. 5

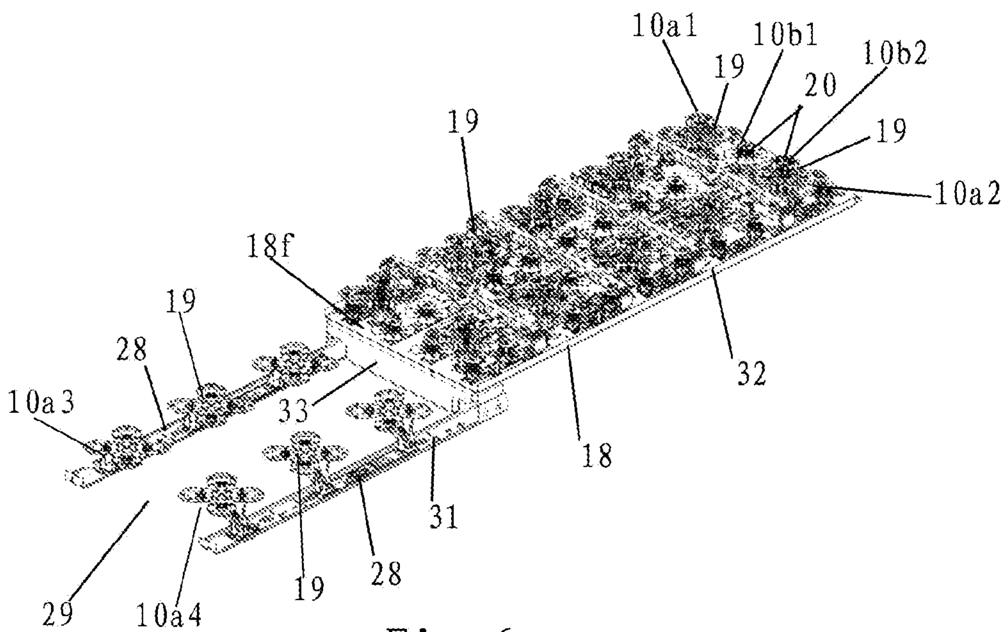
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Fig. 6

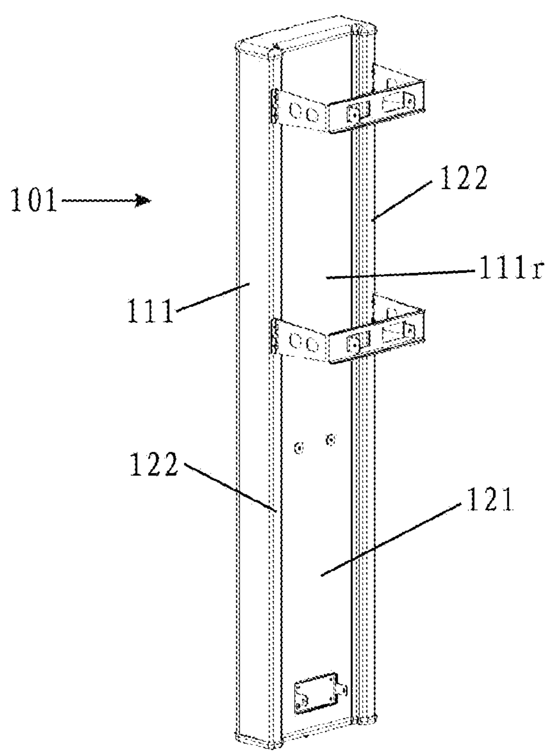
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Fig. 7

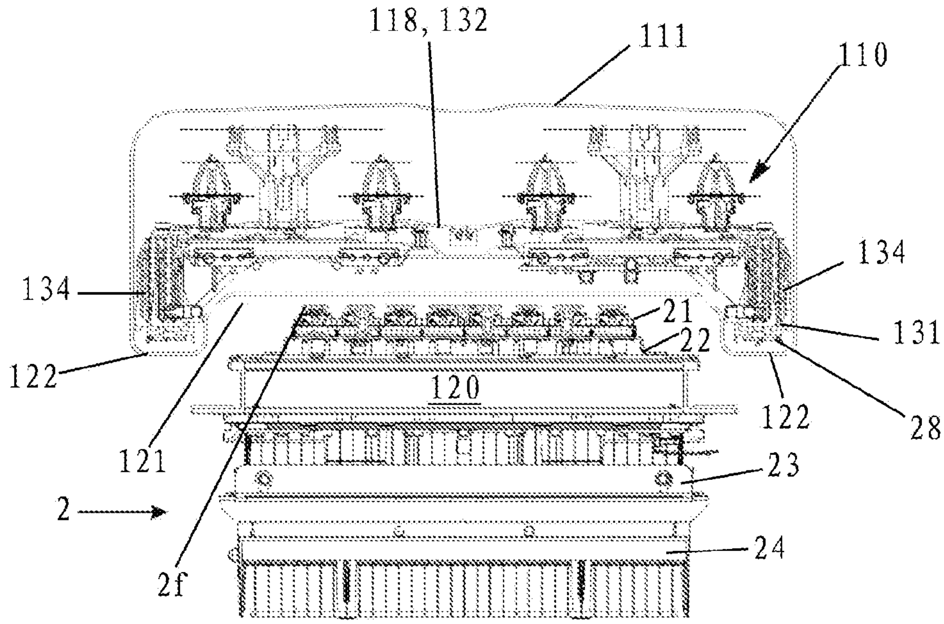

Fig. 8

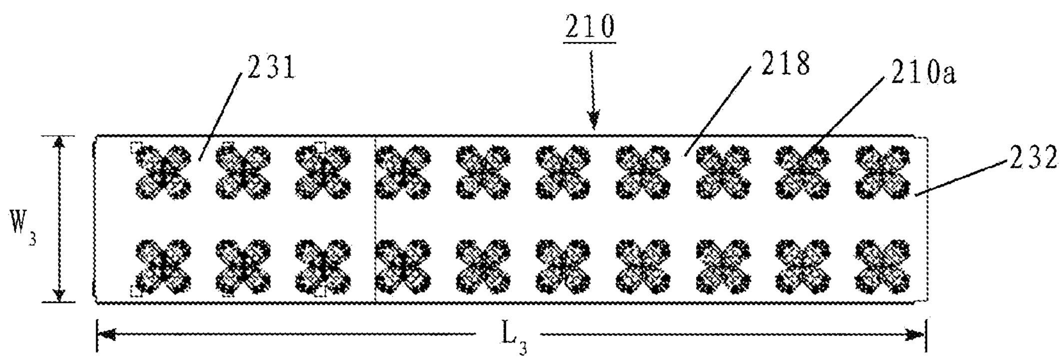

Fig. 9A

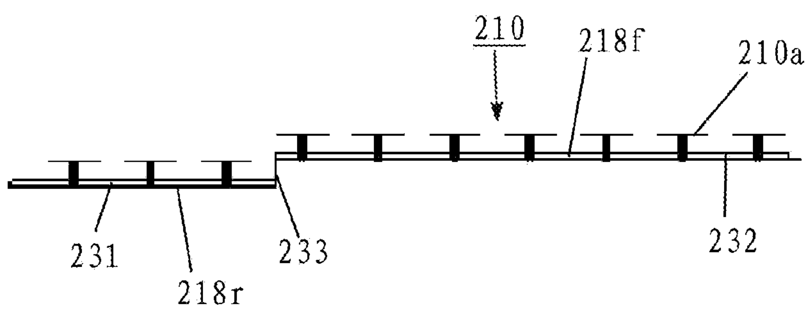

Fig. 9B

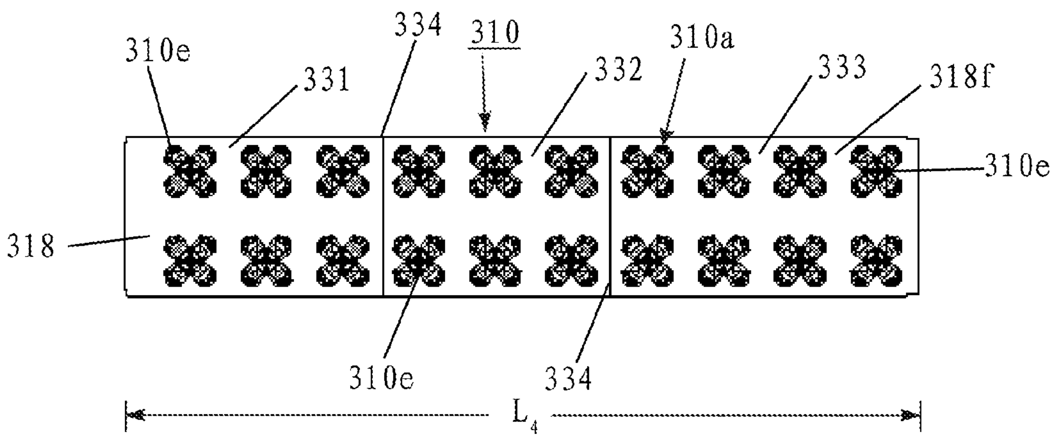

Fig. 10A

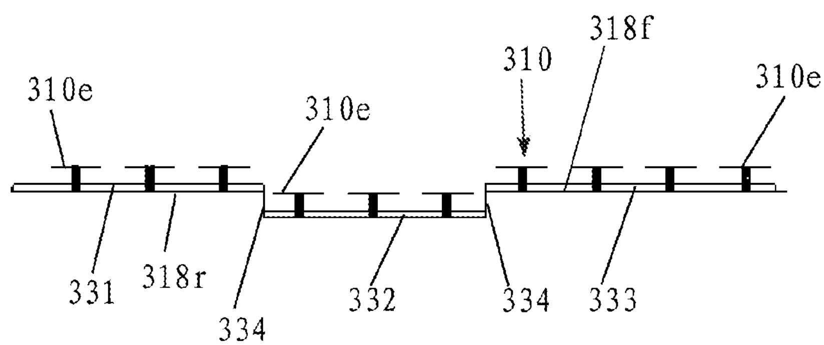

Fig. 10B

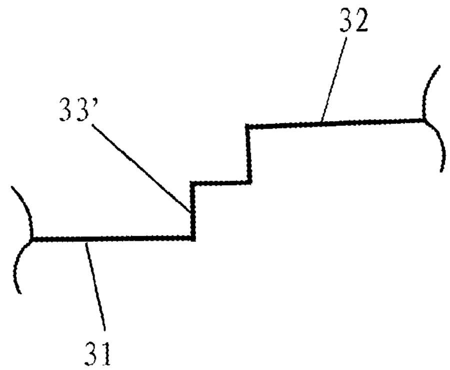

Fig. 11A

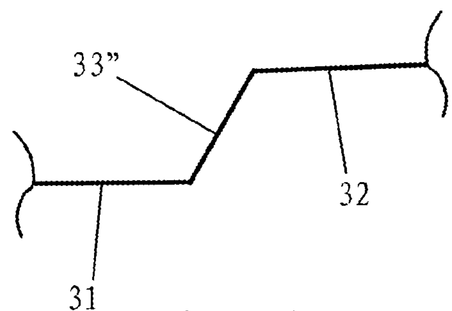

Fig. 11B

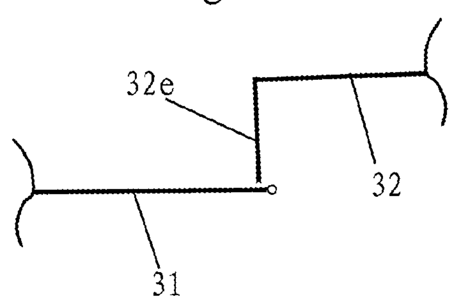

Fig. 11C

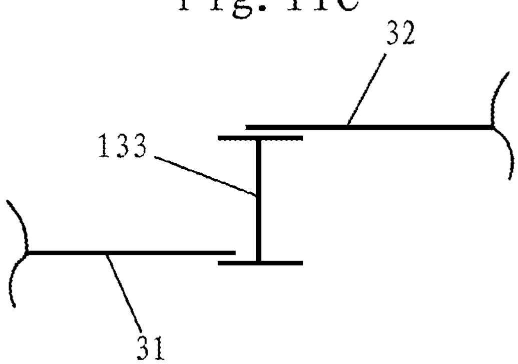

Fig. 12

BASE STATION ANTENNA ARRANGEMENT, BASE STATION ANTENNA AND ANTENNA ASSEMBLY FOR BASE STATION ANTENNA

RELATED APPLICATIONS

This patent application claims the benefit of and priority to Chinese Patent Application Serial Number CN202111149349.8, filed Sep. 29, 2021, the contents of which are hereby incorporated by reference as if recited in full herein.

TECHNICAL FIELD

The present application generally relates to the field of radio communication technology, and more specifically, to an antenna assembly for base station antennas and a base station antenna arrangement as well as a base station antenna comprising such an antenna assembly.

BACKGROUND

Cellular communication systems are known in the art. In cellular communication systems, geographical areas may be divided into a series of cells and each cell may be served by the corresponding base station antenna arrangement.

With the development of 5G communication technology, base station antenna arrangements are becoming increasingly complex. Base station antenna arrangements may comprise a plurality of arrays of radiating elements that operate in different operating frequency bands. One known base station antenna arrangement comprises a passive antenna assembly and an active antenna assembly. It is desirable to use mature passive modules for passive antenna assemblies, as general passive modules are capable of adapting to a variety of active antenna assemblies and are cost-effective.

SUMMARY

The purpose of the present application is to provide an antenna assembly for base station antennas and a base station antenna arrangement comprising such an antenna assembly.

A first aspect of the present application relates to an antenna assembly for base station antennas, where the antenna assembly comprises a reflector, which has a longitudinal extent, a front side and a rear side opposite to the front side, where the front side is configured for radiating elements to be arranged thereon, in which, the reflector has a first longitudinal section residing in a first plane and a second longitudinal section residing in a second plane that is adjacent to the first longitudinal section, where the first plane is rearward of the second plane.

The properties of the base station antenna having the reflector may be improved through an innovative structure of the reflector of the antenna assembly.

In some embodiments, the first longitudinal section may be a longitudinal end section of the reflector.

In some embodiments, the first longitudinal section may be a longitudinal middle section of the reflector. The reflector may comprise two longitudinal end sections as the second longitudinal section. For example, the two second longitudinal sections may be in the same layer or in two different layers in the longitudinal extent of the reflector.

In some embodiments, the first longitudinal section may be transitioned to the second longitudinal section through a step segment.

In some embodiments, the first longitudinal section may be gently transitioned to the second longitudinal section, in which, the transition area may have a continuous curvature in the longitudinal extent.

In some embodiments, the first longitudinal section may have a window extending between laterally spaced apart first and second edge slats that reside on opposing longitudinally extending sides of the window.

In some embodiments, the window may extend only along a longitudinal extent the first longitudinal section.

In some embodiments, the window may extend on a part of the length of the first longitudinal section.

In some embodiments, the window may extend on a large part or the entire length of the length of the first longitudinal section.

In some embodiments, the window may be open on at least one longitudinal end of the first longitudinal section.

In some embodiments, the window may take up a large part, for example, more than ⅔ or more than ¾, of the width of the first longitudinal section.

In some embodiments, the window may be a rectangular window, in which, the edge slats may have straight inner edges.

In some embodiments, the antenna assembly may further comprise a radio frequency (RF) port and an array of radiating elements, wherein each of the radiating elements in the array are coupled to the RF port, and wherein some of the radiating elements in the array are mounted to extend forwardly from the first longitudinal section of the reflector, and other of the radiating elements in the array are mounted to extend forwardly from the second longitudinal section of the reflector.

In some embodiments, the window may extend laterally over at least a major portion of a width of the first longitudinal section.

In some embodiments, the antenna assembly may further comprise a first column of radiating elements that are mounted to extend forwardly from the first edge slat and a second column of radiating elements that are mounted to extend forwardly from the second edge slat.

In some embodiments, each edge slat may be configured for a column or a plurality or columns of radiating elements to be arranged on the front side of the edge slats.

In some embodiments, the antenna assembly may further comprise a dielectric layer extending across at least a portion of the window, in front of the first longitudinal section.

In some embodiments, at least one dielectric supporting element of the one or plurality of dielectric supporting elements may bridge the first and second edge slats of the first longitudinal section.

In some embodiments, in a projection facing the first longitudinal section, the dielectric layer may cover the window.

In some embodiments, the dielectric layer may extend parallel to the first longitudinal section.

In some embodiments, the dielectric layer may be a flat component or a curved component.

In some embodiments, the antenna assembly may comprise one or a plurality of dielectric supporting elements, for example distributed and set on the longitudinal extent of the first longitudinal section, where the supporting elements are fixed to at least one edge slat and supporting the dielectric layer.

In some embodiments, each supporting element may be a planar component bridging and fixed to the two edge slats of the first longitudinal section.

In some embodiments, the antenna assembly may comprise an array of radiating elements extending forward from the front side of the reflector.

In some embodiments, the radiating elements extending forward from the front side of the reflector may be passive radiating elements.

In some embodiments, the antenna assembly may have radiating elements of a unique type.

In some embodiments, the antenna assembly may have two or more types of radiating elements that are capable of working at different frequency bands.

In some embodiments, the radiating elements may be dual-polarized elements, for example, ±45 degrees polarized elements.

In some embodiments, the antenna assembly may further comprise a radio frequency (RF) port and an array of radiating elements, where each of the radiating elements in the array are coupled to the RF port, wherein a first subset of the radiating elements in the array are mounted to extend forwardly from the first longitudinal section of the reflector and a second subset of the radiating elements in the array are mounted to extend forwardly from the second longitudinal section of the reflector, and wherein a forwardmost end of at least some of the radiating elements in the first subset are rearward of forwardmost ends of the radiating elements in the second subset.

In some embodiments, the first longitudinal section may extend along less than half the longitudinal extent of the reflector.

In some embodiments, the reflector may have a third longitudinal section, wherein the third longitudinal section is co-planar with the second longitudinal section, and wherein the first longitudinal section resides between the second and third longitudinal sections.

In some embodiments, a first step segment may reside between the first and second longitudinal sections and a second step segment may reside between the first and third longitudinal segments.

In some embodiments, the antenna assembly may have exactly two longitudinal sections.

In some embodiments, the longitudinal extent of the first longitudinal section may take up a small part of the longitudinal extent of the reflector.

In some embodiments, the longitudinal extent of the first longitudinal section may take up less than 40%, for example approximately ⅓, of the longitudinal extent of the reflector.

In some embodiments, the antenna assembly may have three or more longitudinal sections, in which, every two adjacent longitudinal sections are staggered on the thickness direction of the reflector.

In some embodiments, the three or more longitudinal sections may be in two or more layers.

In some embodiments, every two adjacent longitudinal sections of the reflector may transition to each other through a step.

In some embodiments, each longitudinal section of the reflector may be configured for at least one radiating element to be arranged on the front side of the longitudinal section.

In some embodiments, the first and the second longitudinal sections of the reflector may extend parallel to each other.

In some embodiments, each longitudinal section of the reflector may basically extend in one plane.

In some embodiments, the step segment may comprise a bend in a metal substrate that forms both the first longitudinal section and the second longitudinal section.

A second aspect of the present application relates to a base station antenna arrangement, which comprises a base station antenna, where the base station antenna comprises a housing and an antenna assembly accommodated in the housing, which has a front side associated with the front side of the reflector and a rear side opposite to the front side, in which, the antenna assembly may be the antenna assembly for base station antennas according to the first aspect of the present application.

In some embodiments, the rear side of the housing may be flat.

In some embodiments, the rear side of the housing may have a central concave part extending on one part or the entire length of the longitudinal extent of the housing and rearwardly extending projections, one on each side of the central concave part across a width direction of the housing.

In some embodiments, the width of the central concave part may take up a large part, for example, more than ⅔rds or more than ¾rds, of the width of the housing. "A large part" herein may mean "more than half" and "a small part" may mean "less than half".

In some embodiments, the first longitudinal section of the reflector may comprise first and second edge slats that define a window therebetween, and the first and second edge slats are received in the rearwardly extending projections in the housing.

In some embodiments, the housing may have a rectangular or elliptical cross section.

In some embodiments, the first longitudinal section of the reflector may comprise first and second edge slats that define a window therebetween, and the first and second edge slats are received in the rearwardly extending projections in the housing.

In some embodiments, the base station antenna arrangement may comprise an active antenna module, which may be mounted on the rear side of the housing of the base station antenna behind the first longitudinal section of the reflector.

In some embodiments, the active antenna module may comprise an active reflector and an array of active radiating elements extending forwardly from the active reflector.

In some embodiments, the first longitudinal section of the reflector of the antenna assembly may have a window, and the active radiating elements of the active antenna module extend at least partially through the window.

In some embodiments, the first longitudinal section of the reflector of the antenna assembly may have a window and edge slats that limit the window from two sides on the width direction of the first longitudinal section, and the window may be located in front of the array of active radiating elements.

In some embodiments, in a projection facing the first longitudinal section, the array of active radiating elements may be located inside the window.

In some embodiments, the active reflector of the active antenna module may be capacitively and/or galvanically coupled to the first longitudinal section of the reflector of the antenna assembly, such that the active reflector of the active antenna module and the reflector of the antenna assembly have a common electrical ground/potential.

In some embodiments, the active antenna module may comprise a radio circuitry, an active reflector, and a mMIMO antenna array projecting forwardly from the active reflector.

An aspect of the present invention relates to a base station antenna arrangement comprising:

a base station antenna comprising a passive reflector having a first longitudinal section residing in a first plane and a second longitudinal section residing in a second plane, wherein the first plane is offset from the second plane in a rearward direction, wherein the offset is a distance in a range of 0.25 inches and 5 inches; and an active antenna module comprising an active reflector coupled to the base station antenna behind the first longitudinal section of the passive reflector.

In some embodiments, the active reflector may be electrically coupled to the passive reflector through at least one radome.

In some embodiments, the at least one radome may comprise a radome of the base station antenna that faces the active antenna module and a radome of the active antenna module that faces the radome of the base station antenna.

In some embodiments, the electrical coupling may be a capacitive coupling and/or a galvanic coupling.

In some embodiments, the first and second longitudinal sections may be joined by a stepped segment.

In some embodiments, the stepped segment may be defined by at least one bend in the reflector providing one or both of the first longitudinal section and the second longitudinal section.

In some embodiments, the stepped segment may be provided by a discrete interface member extending in a front to back direction and attached to the first and second longitudinal sections.

In some embodiments, the stepped segment may be perpendicular to the first and second longitudinal sections.

In some embodiments, the base station antenna may further comprise a dielectric material residing across and in front of at least part of the first longitudinal section.

In some embodiments, the base station antenna may further comprise a first column of radiating elements mounted to extend forwardly from a first side of the first longitudinal section and a second column of radiating elements mounted to extend forwardly from the second side of the first longitudinal section, wherein a medial segment of the first longitudinal section is free of radiating elements, and wherein the active antenna module comprises an array of radiating elements that project forwardly behind the medial segment of the first longitudinal section or that extend forwardly into a window in the medial segment of the first longitudinal section.

In some embodiments, an aspect of the present invention relates to a base station antenna, that includes: a first radio frequency (RF) port; a passive reflector having a first longitudinal section residing in a first plane and a second longitudinal section residing in a second plane, where the first plane is offset from the second plane in a rearward direction, and where the offset is a distance in a range of 0.25 inches and 5 inches; and an antenna assembly configured with a first array of radiating elements that are all coupled to the first RF port. A first subset of the radiating elements in the first array are mounted on the first longitudinal section and a second subset of the radiating elements in the first array are mounted on the second longitudinal section.

In some embodiments, the base station antenna may further include a second RF port and the antenna assembly can further include a second array of radiating elements that are all coupled to the second RF port. A first subset of the radiating elements in the second array are mounted on the first longitudinal section and a second subset of the radiating elements in the second array are mounted on the second longitudinal section. The first subsets of the radiating elements in the respective first and second arrays have laterally spaced apart first and second columns of radiating elements on right and left side portions of the first longitudinal section, projecting in a forward direction, and the second subsets of the radiating elements in the respective first and second arrays have laterally spaced apart first and second columns of radiating elements on the second longitudinal section, projecting in the forward direction.

In some embodiments, the first and second arrays of radiating elements may be configured to operate in all or part of the 617-960 MHz frequency band.

In some embodiments, the antenna assembly may further comprise a plurality of radiating elements extending only along the second longitudinal section that are configured to operate in all or part of the 1427-2690 MHz frequency band.

In some embodiments, a major portion of a width dimension of the first longitudinal section may be free of radiating elements.

In some embodiments, the first longitudinal section may comprise a window that extends laterally between right and left side portions of the first longitudinal section and longitudinally along at least a major portion of a length extent of the first longitudinal section, and wherein the right and left side portions comprise radiating elements projecting forward therefrom.

Another aspect of the present invention relates to a base station antenna that includes: a first radio frequency (RF) port; a passive reflector having a first longitudinal section residing in a first plane and a second longitudinal section residing in a second plane. The first plane is offset from the second plane in a rearward direction. The base station antenna also includes a first array of radiating elements that are coupled to the first RF port, where at least some of the radiating elements in the first array are mounted to extend forwardly from the first longitudinal section of the reflector; and an active antenna module that includes an active reflector and an array of active radiating elements extending forwardly from the active reflector. The active reflector is substantially coplanar with the first longitudinal section of the passive reflector.

In some embodiments, others of the radiating elements in the first array may be mounted to extend forwardly from the second longitudinal section of the passive reflector.

In some embodiments, the active antenna module may be mounted behind the first longitudinal section of the passive reflector.

In some embodiments, the active reflector may be electrically coupled to the passive reflector.

In some embodiments, the active reflector may be coupled to the passive reflector through a frame that is used to mount the active antenna module to the base station antenna.

In some embodiments, the first longitudinal section of the passive reflector may include a window, and wherein the active radiating elements extend forwardly from the active reflector to pass at least partially through the window.

The above-mentioned technical features, the technical features to be mentioned below and the technical features shown separately in the drawings can be arbitrarily combined with each other as long as the combined technical features are not contradictory. All feasible feature combinations are technical contents clearly included herein.

BRIEF DESCRIPTION OF THE DRAWINGS

Now, exemplary embodiments of the present disclosure are described with reference to the schematic drawings.

FIG. **1** is a rear perspective view of a base station antenna arrangement according to embodiments of the present invention.

FIG. **2** is an exploded, rear perspective view of the base station antenna arrangement of FIG. **1**.

FIG. **3** is a lateral cross-sectional view of the base station antenna arrangement of FIG.

FIG. **4** is a side view of an antenna assembly of the base station antenna arrangement of FIG. **1**.

FIG. **5** and FIG. **6** are two different perspective views of the base station antenna assembly of FIG. **4**.

FIG. **7** is a rear perspective view of a housing of a base station antenna arrangement according to embodiments of the present disclosure.

FIG. **8** is a lateral cross-sectional view of a base station antenna arrangement that includes the housing of FIG. **7**.

FIGS. **9**A and **9**B are a top view and a side view, respectively, of an antenna assembly according to further embodiments of the present invention.

FIGS. **10**A and **10**B are a top view and a side view, respectively, of an antenna assembly according to yet additional embodiments of the present invention.

FIGS. **11**A-**11**C and **12** are schematic illustrations of additional embodiments of stepped segments that may be used to join first and second longitudinal sections of a reflector according to embodiments of the present invention.

DETAILED DESCRIPTION

Referring to FIGS. **1**-**3**, a base station antenna arrangement is shown that includes a base station antenna **1** and an active antenna module **2** attached to the base station antenna **1**. The base station antenna **1** has a housing **11**. The housing **11** may be substantially rectangular with a flat rectangular cross-section. The housing **11** may have a front side **11***f* and a rear side **11***r* opposite the front side **11***f*, two (narrow) sidewalls **11***s* facing each other and extending between the front side **11***f* and the rear side **11***r*, a top side **11***t* and a bottom side **11***b* opposite the top side **11***t*. Typically, the top side **11***t* of the housing **11** may be sealed in a waterproof manner and may comprise an end cap and the bottom side **11***b* of the housing **11** may be sealed with a separate end cap **30**. The front side **11***f*, the sidewalls **11***s* and possibly the rear side **11***r* of the housing **11** may comprise a radome that is substantially transparent to radio frequency (RF) energy within the operating frequency bands of the base station antenna **1**. The radome may be formed of, for example, fiberglass or plastic. An antenna assembly **10** of base station antenna **1** (shown in FIG. **4**) may be slidably inserted, optionally pushed from the bottom side **11***b* of the housing **11**, into the housing **11**. However, other assembly methods may be used, such as inserting the antenna assembly **10** from the top side **11***t* of the housing **11**.

The active antenna module **2** may be attached to the base station antenna **1** at the rear side **11***r* of the housing **11** of the base station antenna **1**. The rear side **11***r* of the housing **11** may be a flat surface extending along a common plane over an entire longitudinal extent thereof or along at least a portion of the longitudinal extent thereof. The rear surface **11***r* can comprise a plurality of longitudinally spaced apart mounting structure brackets, shown as upper, medial, and lower brackets, **15**, **16**, **17**, respectively, that extend rearwardly from the housing **11**. In some embodiments, the mounting structure brackets **15**, **16**, **17** may be configured to couple to one or more mounting structures such as, for example, a tower, pole or building (not shown). At least two of the mounting structure brackets **15**, **16** can also be configured to attach to a frame **12** of the base station antenna arrangement. The frame **12** may extend over a sub-length of a longitudinal extent L_1 of base station antenna **1**, where the sub-length is shown in FIG. **1** as being at least a major portion thereof. The frame **12** can comprise a top **12***t*, a bottom **12***b* and two opposing long sides **12***s* that extend between the top **12***t* and the bottom **12***b*. The frame **12** can have an open center space **12***c* extending laterally between the long sides **12***s* and longitudinally between the top **12***t* and bottom **12***b*.

The active antenna module **2** can be configured to attach to the frame **12** using a plurality of accessory brackets, shown as a first accessory bracket **13** and a second accessory bracket **14**. The first accessory bracket **13** can attach to a top portion **2***t* of the active antenna module **2** and to a rear **2***r* of the active antenna module **2**. The second accessory bracket **14** can span laterally below the first accessory bracket **13** and may be fixed to the opposing two sides **12***s* of the frame **12**. Thus, the frame **12** can attach the active antenna module **2** to the base station antenna **1**.

The frame **12** may be configured so that a variety of different active antenna modules **2** can be mounted to the frame **12** using appropriate accessory brackets **13**, **14**. As such, a variety of active antenna modules **2** may be interchangeably attached to the same base station antenna **1**.

The different active antenna modules **2** may attach to the same configuration of the frame **12** or a different configuration of the frame **12** using the same accessory brackets **13**, **14** or using a plurality of the second accessory brackets **14** without requiring the first accessory (top) bracket **13**. Other configurations of accessory brackets **14** may be used. The different active antenna modules **2** that may be attached to the frame **12** may have different dimensions, for example, different lengths and/or different widths and/or different thicknesses.

In some embodiments, a plurality of active antenna modules **2** may be concurrently attached to the same base station antenna **1** at different longitudinal locations using one or more frames **12**. Such active antenna modules **2** may have different dimensions, for example, different lengths and/or different widths and/or different thicknesses.

The term "active antenna module" is used interchangeably with "active antenna unit" and "AAU" and refers to a cellular communications unit comprising radio circuitry and associated radiating elements. The radio circuitry is capable of electronically adjusting the amplitude and/or phase of the subcomponents of an RF signal that are output to different radiating elements of an array or groups thereof. The active antenna module **2** comprises the radio circuitry and the radiating elements (e.g., a massive multi-input-multi-output (mMIMO) beamforming antenna array) and may include other components such as filters, a calibration network, an antenna interface signal group (AISG) controller and the like. The active antenna module **2** can be provided as a single integrated unit or provided as a plurality of stackable units, including, for example, first and second sub-units such as a radio sub-unit (box) with the radio circuitry and an antenna sub-unit (box) with a multi-column array of radiating elements and the first and second sub-units stackably attach together in a front to back direction of the base station antenna **1**, with the antenna unit **120** (FIG. **3**) closer to the front **11***f* of the housing **11** of base station antenna **1** than the radio circuitry unit **23**. In some embodiments, the radiating elements may comprise a separate sub-unit from the radio circuitry and the radiating element sub-unit may be mounted within the base station antenna **1** instead of being external to the base station antenna **1**.

As will be discussed further below, the base station antenna **1** includes an antenna assembly **10**, which can be referred to as a "passive antenna assembly". The term "passive antenna assembly" refers to an antenna assembly having arrays of radiating elements that are coupled to radios that are external to the antenna, typically remote radio heads that are mounted in close proximity to the base station antenna **1**. The arrays of radiating elements included in the passive antenna assembly are configured to form static antenna beams (e.g., antenna beams that are each configured to cover a sector of a base station). The passive antenna assembly can comprise radiating elements such as one or more linear arrays of low band radiating elements that operate in all or part of the 617-960 MHz frequency band and/or one or more linear arrays of mid-band radiating elements that operate in all or part of the 1427-2690 MHz frequency band. The passive antenna assembly **10** is mounted in the housing **11** of base station antenna **1** and one or more active antenna modules **2** can releasably (detachably) couple (e.g., directly or indirectly attach) to base station antenna **1** via the frame **12**.

FIG. **4** is a side view of an example antenna assembly **10** provided inside the base station antenna **1**. FIG. **5** is a perspective view of the antenna assembly **10**, in which a dielectric material component **25** that is shown in FIG. **4** is removed. FIG. **6** is another perspective view of the antenna assembly **10**, in which components **25**, **26**, and **27** and end cover **30** shown in FIG. **4** and FIG. **5** are removed to more clearly show an example reflector **18** of the antenna assembly **10**.

The reflector **18** has a longitudinal extent L_2 and a lateral extent W_2. The reflector **18** has a front side **18*f*** and rear side **18*r*** opposite the front side **18*f***. The front side **18*f*** of the reflector **18** faces the front side **11*f*** of the housing **11** and the rear side **18*r*** of the reflector **18** faces the rear side **11*r*** of the housing **11**. The antenna assembly **10** comprises multiple arrays of radiating elements **10*a*1**, **10*a*2**, **10*b*1**, **10*b*2**, **10*c*1**, **10*c*2** that extend forwardly from the front side **18*f*** of the reflector **18**. The arrays of radiating elements **10*a*1**, **10*a*2**, of the antenna assembly **10** may comprise radiating elements **19** that are configured to operate in a first frequency band. The arrays of radiating elements **10*b*1**, **10*b*2** of the antenna assembly **10** may comprise radiating elements **20** that are configured to operate in a second frequency band. The arrays of radiating elements **10*c*1**, **10*c*2**, of the antenna assembly **10** may comprise radiating elements **34** that are configured to operate in either the second frequency band or in a third frequency band. The first, second and third frequency bands may be different frequency bands (although potentially overlapping).

Referring to FIGS. **4-6**, the reflector **18** may have a first longitudinal section **31** and a second longitudinal section **32** that is adjacent the first longitudinal section **31**, where the first longitudinal section **31** is longitudinally spaced apart from the second longitudinal section **32** and the second longitudinal section **32** is in a plane that is forwardly offset from a plane of the first longitudinal section **31**. The first longitudinal section **31** may be a longitudinal end section of the reflector **18**, shown as a top end section but it is contemplated that the first longitudinal section **31** may be provided as a medial or bottom end section in other embodiments. The offset, measured in a front-to-back direction in an installed orientation, may, for example, be in a range of 0.25 inches to 5 inches, more typically 0.5 inches to 3 inches.

The first longitudinal section **31** may take up a sub-length of, for example, about 20-40%, such as about 30%, in some embodiments, of the longitudinal extent L_2 of the reflector **18**. It will be appreciated, however, that with shorter antennas the first longitudinal section **31** may take up a sub-length of more than 50% of the longitudinal extent L_2 of the reflector **18**. As shown in FIG. **4** to FIG. **6**, the first longitudinal section **31** can transition to the second longitudinal section **32** through a step or step segment **33**. The step segment **33** can be (but need not necessarily be) perpendicular to the first and second longitudinal sections **31**, **32**. FIGS. **11**A, **11**B, show other configurations of the step segment **33'**, **33"** according to further embodiments of the present invention.

The first and second longitudinal sections **31**, **32** and the step segment **33** can be monolithically formed as a unitary metal body in some embodiments. In other words, the first longitudinal section **31**, the second longitudinal section **32** and the step segment **33** may all comprise a single piece of metal. The step segment **33** can be provided as a bent segment of the reflector **18**. Alternatively, the first and second longitudinal sections **31**, **32** can be separate components and the step segment **33** can be provided by a separate component such as an interface member **133** (FIG. **12**) that is attached to the first and second longitudinal sections **31**, **32** and/or that is capacitively coupled to the first and second longitudinal sections **31**, **32**. In yet other embodiments, the step segment **33** can be a shaped extension **32*e*** of one of the longitudinal components **31**, **32** as shown in FIG. **11**C so that the first longitudinal section **31**, the second longitudinal section **32** and the step segment **33** are formed from two pieces of metal. The step segment **33'** can comprise a plurality of steps (FIG. **11**A) and/or an angled segment **33"** (FIG. **11**B) that is at an angle of, for example, 30-70 degrees with respect to the planes defied by the first and second longitudinal sections **31**, **32**. Each longitudinal section **31**, **32** may substantially extend in different planes. The first and second longitudinal sections **31**, **32** can be substantially parallel to each other and reside a distance apart in a range of 0.5 inches to 2 inches, in some embodiments, and 0.5 inches to 3 inches or 0.5 inches to 5 inches in other embodiments. The term "substantially parallel" means that the primary planes of each longitudinal section **31**, **32** are within +/−10 degrees of each other over the respective longitudinal extents thereof.

The first longitudinal section **31** may have two laterally spaced apart and longitudinally extending edge slats **28** that may define a window **29** therebetween. The window **29** may extend a sub-length of or the entire length of the longitudinal extent of the first longitudinal section **31**. The window **29** may be enclosed on all sides or may be open on at least one side.

Referring to FIGS. **3** to **6**, on the second longitudinal section **32**, the antenna assembly **10** may comprise two columns of first radiating elements **19** with a lower working frequency, two columns of second radiating elements **20** with a higher working frequency than the first radiating elements **19**, and two columns of third radiating elements **34** with a higher working frequency than the first radiating elements **19**. The second radiating elements **20** and the third radiating elements **34** may be configured to operate in the same or different operating frequency bands. In the width direction of the second longitudinal section **32**, the columns of second radiating elements **20** may be positioned between the columns of first radiating elements **19**. The columns of first radiating elements **19** and second radiating elements **20** may be positioned between the two columns of third radiating elements **34**.

First and second columns of first radiating elements **19** may also be respectively arranged on the two edge slats **28** on the first longitudinal section **31**. The first column of first radiating elements **19** on the second longitudinal section **32** and the first column of first radiating elements **19** on the first longitudinal section **31** may together form a first linear array of first radiating elements that are all coupled to a common RF port of base station antenna **1** (or to two common RF ports if the first radiating elements **19** are dual polarized radiating elements). The second column of first radiating elements **19** on the second longitudinal section **32** and the second column of first radiating elements **19** on the first longitudinal section **31** may together form a second linear array of first radiating elements **19** that are all coupled to another common RF port of base station antenna **1** (or to two other common RF ports if the first radiating elements **19** are dual polarized radiating elements). The two columns of second radiating elements **20** may likewise form two additional linear arrays, and the two columns of third radiating elements **34** may form another two linear arrays. An upper and a lower column of RF ports **30***a* on the end cap **30** are shown exemplarily in FIG. **4**. The various radiating elements of the (passive) antenna assembly **10** may be referred to as passive radiating elements, and the linear arrays that these radiating elements form may be referred to as passive linear arrays.

The first radiating elements **19** that are mounted on the first longitudinal section **31** of the stepped reflector **18** are mounted farther rearwardly than the first radiating elements **19** that are mounted on the second longitudinal section **32** of the stepped reflector **18**. To ensure that the antenna beams generated by the arrays **10***a***1**, **10***a***2** that include the first radiating elements **19**, phase compensation may be applied to the first radiating elements **19** that are mounted on the first longitudinal section **31** with respect to the first radiating elements **19** that are mounted on the second longitudinal section **32** so that the RF energy emitted by these first radiating elements will constructively combine to form a desired wavefront.

In the embodiment of FIGS. **1-6**, only the first radiating elements **19** extend onto the first longitudinal section **31** of the reflector **18**. It will be appreciated, however, that embodiments of the present invention are not limited thereto. For example, in other embodiments, the arrays **10***c***1**, **10***c***2** of the third radiating elements **34** may be lengthened by including additional radiating elements **34** in each array **10***c***1**, **10***c***2**, where the additional radiating elements **34** are mounted on the respective first and second edge slats **28** of the first longitudinal section **31** of the reflector **18**. Thus, it will be appreciated that first radiating elements **19** and/or third radiating elements **34** may be mounted on each edge slat **28** of the first longitudinal section **31** of the reflector **18**, and that the arrays **10***c***1**, **10***c***2** may also or alternatively span both the first and second longitudinal sections **31**, **32** of the reflector **18**. In other embodiments, the radiating elements mounted on the first longitudinal section **31** could comprise separate arrays so that the antenna included vertically stacked arrays. For example, the depicted embodiment of FIGS. **1-6** could be modified so that the two columns of first radiating elements **19** that are mounted on the second longitudinal section **32** of the reflector **18** could be coupled to respective RF first and second ports to form first and second arrays **10***a***1**, **10***a***2** of first radiating elements **19**, and the two columns of first radiating elements **19** that are mounted on the first longitudinal section **31** of the reflector **18** could be coupled to respective third and fourth RF ports to form third and fourth arrays **10***a***3**, **10***a***4** of first radiating elements **19**.

As shown in FIG. **5**, the first longitudinal section **31** of the reflector **18** may optionally include a connecting strip **27** on the end part so that the window **29** may be fully enclosed. The connecting strip **27** may connect the two edge slats **28** of the first longitudinal section **31** of the reflector **18** such that the first longitudinal section **31** is more stable. The connecting strip **27** may be made of dielectric material(s) in some embodiments. A planar dielectric layer **25** may be set in front of at least part of the first longitudinal section **31**. For this option, the antenna assembly **10** may comprise a plurality of supporting elements **26** that are longitudinally spaced apart and coupled to the first longitudinal section **31**. The supporting elements **26** may be planar components bridging and fixed to the two edge slats **28** of the first longitudinal section **31** and may be used to mount the dielectric layer **25** forwardly of the window **29**. The planar dielectric layer **25** may comprise a matching layer that is configured to reduce return loss and/or passive intermodulation distortion, for example.

In the cross-section shown in FIG. **3**, the housing **2***h* of the active antenna module **2** is removed to show the internal structure of an example active antenna module **2**. More specifically, the active antenna module **2** may comprise two sub-units, that is, an antenna unit **120** at the front side and radio circuitry **23** at the rear side. These two units **120**, **23** may have respective housings and may be mechanically and electrically connected to each other. The housing **120***h* of the antenna unit **120** may include a radome. The radio circuitry **23** may be equipped with a cooling device **24**. The cooling device may have a metal fin structure and/or may be a controlled fan. The active antenna module **2** may also be provided as an integrated unit with a single housing **2***h* and without requiring the radio circuitry **23** to be a separate stacked unit. Rather, the radio circuitry **23** can be integrated inside a single housing/radome.

The active antenna module **2** may comprise a reflector **22** and an array of active radiating elements **21** extending forwardly from the reflector **22**. The reflector **22** may be provided, for example, as a sheet metal reflector or as a metal ground plane of a printed circuit board. The reflector **22** of the active antenna module **2** may be referred to herein as an "active reflector" and the reflector **18** of the base station antenna **1** may be referred to herein as a "passive reflector" for ease of discussion.

The active antenna module **2**, for example, may be configured for 5G communication services. The radiating elements **21** of the active antenna module **2** may have a higher working frequency than the (passive) radiating elements **19**, **20** and **34** of the base station antenna **1**. The radiating elements **21** may work at a high frequency band, for example, at a frequency band of 3,300-4,200 MHz. The radiating elements **21** can be provided as a massive MIMO (mMIMO) array of radiating elements in some embodiments.

The active reflector **22** can cooperate with the passive reflector **18** and the two can be configured to functionally act as a single reflector that resides behind various of the radiating elements. For example, some of the lower-band radiating elements **19** project forwardly from the first longitudinal section **31** of the passive reflector **18** and also laterally extend in front of and over an adjacent segment of the active reflector **22**. The two reflectors **18**, **21** may thus act as single reflector for the lower-band radiating elements **19** that laterally extend in front of and over the active reflector

22. At the same time, the passive reflector **18** does not impede the performance of the active radiating elements **21** of the active antenna module **2**. For example, the active reflector **22** may be configured to be substantially coplanar with the first longitudinal section **31** of the passive reflector **18**. As such, the first longitudinal section **31** of the passive reflector **18** may not substantially block RF energy emitted by the active radiating elements. Herein, the active reflector **22** is considered to be "substantially coplanar" with the first longitudinal section **31** of the passive reflector **18** if a plane defined by the active reflector is positioned within 0.5 inches either forwardly or rearwardly of a plane defined by the first longitudinal section **31** of the passive reflector **18**.

In conventional base station antennas, the internal reflectors have respective longitudinal extents that extend in a straight line (viewed from the side), e.g., the reflectors extend is in a single plane over their longitudinal extents. In the exemplary embodiments according to the present invention, the passive reflector **18** may be curvilinear, when viewed from the side (FIGS. **4-6**), in the longitudinal direction, in which, the passive reflector **18** of the base station antenna **1** can reside sufficiently close to the active reflector **22** of the active antenna module **2** in the first longitudinal section **31** such that the two reflectors **18** and **22** may be electrically coupled through, for example, a radome of the base station antenna **1** and the active antenna module **2** and the two reflectors **18** and **22** can therefore have a common electrical ground or electrical potential. The passive reflector **18** and the active reflector **22** can be capacitively coupled and/or galvanically coupled to each other to provide this common ground potential. An electrical ground path can extend between the active reflector **22** and the passive reflector **18** via various internal and external components to provide the common electrical ground reference.

The passive reflector **18** can be capacitively and/or galvanically coupled to the active reflector **22** at one or more locations. For example, in some embodiments, the passive reflector **18** can be capacitively coupled to the active reflector **22** through a radome of the active antenna module **2** and/or through a radome that is part of the housing **11** of the base station antenna **1**. More specifically, the electrical coupling can be through the rear side **11***r* of the housing **11** of the base station antenna **1** and through the front **2***f* of the radome of the active antenna module **2**, and/or through the sidewalls **11***s* of the housing **11** and the side **2***s* of the active antenna module **2**, and/or through a top and bottom **2***t*, **2***b* of the active antenna module **2** and frame **12** through housing **11**. In one specific embodiment, the frame **12** may be configured to galvanically or capacitively couple to the first longitudinal section **31** of the passive reflector **18**. The frame **12** may also be configured to galvanically or capacitively couple to a housing of the active antenna module, and the housing of the active antenna module **2** may be galvanically or capacitively coupled to the active reflector **22**. Thus, the frame **12** may be located along an electrical path that provides a common ground reference between the passive reflector **18** and the active reflector **22**. As noted above, the rear side **11***r* and sidewalls **11***s* of housing **11** may comprise portions of the radome of the base station antenna **1**. Through the configuration of the reflector **18**, a combined base station antenna arrangement comprising a general passive module defined by the base station antenna **1** and a variety of active antenna modules **2** may be provided, in which, the various reflectors of each can have a common earth (ground) potential.

The window **29** of the first longitudinal section **31** of the reflector **18** of the antenna assembly **10** is located in front of the radio circuitry of the active antenna module **2**. In some embodiments, the active radiating elements **21** may be located rearwardly of the window **29**. This may advantageously allow the rear side **11***r* of the housing **11** to be flat. It will be appreciated, however, that in other embodiments the base station antenna arrangement may be configured so that the active radiating elements **21** may extend forwardly at least partially through the window **29**. The window **29** can have a lateral and longitudinal extent with a perimeter that corresponds to a perimeter of the array of radiating elements **21**. The window **29** can have a lateral extent that is greater than a sum of the lateral extents of each edge slat **28**.

In some embodiments, referring to FIG. **4**, a dielectric layer **25** can be positioned in front of the first longitudinal section **31** of the antenna assembly **10** to provide a compensating effect to the active antenna module **2** for the front radome of housing **11**. The dielectric layer **25** may be a flat component or curved or otherwise shaped component. The dielectric layer **25** may partially or completely cover the window **29**, for example, it may partially or completely cover the window **29** along a length thereof and laterally across the entire first longitudinal section **31** and may reside in front of at least some of the radiating elements **19** and/or **21**.

Referring to FIG. **4**, the dielectric layer **25** may reside in front of the radiating elements **19** that are mounted on the first longitudinal section **31** in a plane P_2 that is substantially aligned with (+/−0.25 inches) a plane P_1 extending along the second longitudinal section **32** of the reflector **18** with plane P_1 defined by forwardmost ends **10***e* of radiating elements **19** that project forwardly from the second longitudinal section **32** (FIG. **4**).

The dielectric layer **25** may be provided by a multiple layer printed circuit board or a flex circuit or other dielectric material or substrate. Referring to FIGS. **7** and **8**, a base station antenna **101** with a housing **111** according to further embodiments of the present invention is shown. The housing **111** may comprise or include a radome. The active antenna module **2** of the base station antenna arrangement according to this embodiment may have the same configuration as the base station antenna **1** that is discussed above, and thus the relevant illustrations and descriptions may be referenced. The active antenna module **2** is omitted from FIG. **7** to more clearly show the rear side **111***r* of the housing **111** of the base station antenna **101**.

In the base station antenna **101**, the antenna assembly **110** (FIG. **8**) may have a similar configuration as the antenna assembly **10** of the base station antenna **1** that is discussed above, and the reflector **118** of the antenna assembly **110** may have the same or a similar configuration to the reflector **18** of base station antenna **1**.

The rear side **111***r* of the housing **111** may have a central recessed or concave segment **121** that extends over a sub-length or the entire length of the longitudinal extent of the housing **111** and rearwardly projecting segments **122** can extend on each side of the central segment **121** that limit the central concave part **121** from two sides across the width direction of the housing **111**. In some embodiments, the central recessed segment **121** of the housing **111** may comprise a portion of a radome of the housing **111**.

Referring to FIG. **8**, the passive reflector **118** can have the same or a similar configuration as the passive reflector **18** shown in FIG. **4** to FIG. **6**. The passive reflector **118** may be placed in the housing space of the longitudinal extent limited by the rearwardly projecting segments **122** of the housing **111** through the first longitudinal section **131** thereof, and the reflector **118** may be placed on or adjacent the inner surface of the central concave part **122** of the housing **111** through the second longitudinal section **132** thereof. The second longitudinal section **132** may be arranged with an array of first radiating elements **119**, an array of second radiating elements **120** and an array of third radiating elements **134** (configured same or similar to the radiating elements **19**, **20**, **34**) that work at two or more different frequency bands, and the first longitudinal section **131** may be arranged with additional columns of first radiating elements **119** (corresponding to the first radiating elements **19**, FIG. **5**) on the respective edge slats **28** thereof that are part of the arrays of first radiating elements **119** that are mounted on the second longitudinal section **132**. Due to the concave design of the rear side of the housing **111**, the antenna assembly **110** may not have supporting elements **26** that are present in the base station antenna **1** according to the first embodiment. As shown in FIG. **8**, a front **2***f* of the active antenna module **2** can be configured to reside in the central concave segment **122**.

FIGS. **9**A and **9**B are a top view and side view of an antenna assembly **210** according to still further embodiments of the present invention. The antenna assembly **210** may be used as the main structural unit of the base station antenna accommodated in a housing (such as housing **11**, **111**, FIG. **1**, **7**) that is not shown. The antenna assembly **210** may comprise a reflector **218**, which has a longitudinal extent L_3 and a lateral extent W_3. The reflector **218** may have a front side **218***f* and rear side **218***r* opposite the front side. First and second arrays of radiating elements **210***a* are mounted to extend forwardly from the front side **218***f* of the reflector **218**.

The reflector **218** may have a first longitudinal section **231** and a second longitudinal section **232** adjacent the first longitudinal section **231**, where the first longitudinal section **231** is in a plane that is rearwardly offset relative to a plane of the second longitudinal section **232**. The first longitudinal section **231** may be a longitudinal end section of the reflector **218**. The first longitudinal section **231** may take up a sub-length of the reflector **218**, for example, about 30-40%, of the longitudinal extent L_3 of the reflector **218**. The first longitudinal section **231** may transition to the second longitudinal section **232** through a step segment **233** like that 33 as discussed above with respect to reflector **18**. The longitudinal sections **231**, **232** may be parallel to each other. As shown, the radiating elements **210***a* in the two arrays extend forwardly from both the first longitudinal section **231** and the second longitudinal section **232**. In other words, each array spans both the first and second longitudinal sections **231**, **232**. The first longitudinal section **231** can be continuous in a lateral direction to define a continuous surface and sides and no window is included.

In this embodiment, the first longitudinal section **231** of the passive reflector **218** (or at least a portion thereof) can be configured to selectively reject (e.g., reflect) RF energy in some frequency ranges while permitting RF energy in other frequency ranges to pass therethrough by forming the first longitudinal section **231** of the passive reflector **218** as a frequency selective surface and/or substrate to operate as a type of "spatial filter". See, e.g., Ben A. Munk, Frequency Selective Surfaces: Theory and Design, ISBN: 978-0-471-37047-5; DOI: 10.1002/0471723770; April 2000, Copyright © 2000 John Wiley & Sons, Inc. the contents of which are hereby incorporated by reference as if recited in full herein. For additional discussion of example configurations of the frequency selective surface embodiments, see co-pending U.S. patent application Ser. No. 17/209,562 filed Mar. 23, 2021, the contents of which are hereby incorporated by reference as if recited in full herein. The frequency selective surface may be configured to reflect RF energy in the operating frequency range of the radiating elements **210***a*, so that the frequency selective surface will act as a reflector for those radiating elements. The frequency selective surface may be configured to substantially pass RF energy in the operating frequency range of the radiating elements of an array included in an active module of the antenna (not shown) so that RF energy emitted by the active radiating elements, which are positioned behind the frequency selective surface, may pass through the frequency selective surface and exit the front of the antenna.

FIGS. **10**A and **10**B are a top view and side view of an antenna assembly **310** according to yet another embodiment of the present invention.

The antenna assembly **310** comprises a reflector **318**, which has a longitudinal extent L_4. The reflector **318** may have a front side **318***f* and rear side **318***r* opposite the front side **318***f*. A pair of arrays of radiating elements **310***a* extend forwardly from the front side **318***f* of the reflector **318**.

The reflector **318** may have a first longitudinal section **332** residing between second and third longitudinal sections **331** and **333**, respectively, adjacent the first longitudinal section **332**, where the first longitudinal section **332** is in a plane that is offset in a rearward direction relative to a plane or planes corresponding to the second and third longitudinal sections **331**, **333**. The first longitudinal section **332** may be a longitudinal central section of the reflector **318** and the second and third longitudinal sections **331** and **333** may be opposing upper and lower end sections of the reflector **318**. The first longitudinal section **332** may transition to the second longitudinal sections **331** and **333** through respective step segments **334**. Thus, each longitudinal section **331**, **332**, **333** may extend in a plane. The longitudinal sections **331**, **332**, **333** may be parallel to each other. The second and third second longitudinal sections **331**, **333** may be coplanar. Each longitudinal section **331**, **332**, **333** of the reflector may be arranged with at least one radiating element **310***e*. In FIGS. **10**A and **10**B, the first longitudinal section **331** does not include a window and may include a frequency selective surface, as discussed above with reference to the embodiment of FIGS. **9**A-**9**B. It will be appreciated that in other embodiments a window may be provided in the first longitudinal section **331** in the manner described above with reference to the embodiment of FIGS. **4**-**6**.

While not shown in the drawings, it will be appreciated that in other embodiments, the first longitudinal section **332** shown in FIG. **10**B may be positioned forwardly of the second and third longitudinal sections **331** and **333**. Such a configuration may be appropriate when two active antenna modules are mounted to the antenna that includes the antenna assembly **310**. In such embodiments, the two active antenna modules may be mounted behind the second and third longitudinal sections **331** and **333** so that the passive reflector would extend close to the active antenna modules.

In the antenna assemblies **10**, **110**, **210**, **310**, as the first longitudinal section **31**, **131**, **231**, **332**, is rearwardly offset in the front-to-back direction of the base station antenna **1** relative to the second longitudinal section **32**, **132**, **232**, **331** (where the reflector can be described as a "stepped reflector"), and as compared to the situation where the reflector extends in a straight line (side view) in the longitudinal extent, the amplitude and phase of the radiating elements on the first longitudinal section change such that the electrical properties of the entire antenna assembly, for example, the front-to-back ratio, sector power ratio, and half power beam width, etc. can be improved.

The stepped passive reflectors **18**, **118**, **218**, **318** can be configured to position the passive reflector segment that resides in front of the active antenna module **2** to be closer to the active reflector **22** of the active antenna module without requiring (or at least limiting the extent to which) the active antenna module **2** to be pushed forward into the base station antenna **1**. The stepped passive reflector can advantageously compensate phase for a low band wavefront for low band radiating elements that are at different heights (different low band radiating elements can extend forward at different height dimensions from different reflector planes) so that a wavefront is compensated to be at the same phase across the antenna.

In some embodiments, a constant profile of the rear **11***r*, **111***r* of the housing over its longitudinal extent can be provided by the base station antenna **1** with the housings having extruded radomes with a common profile over an entire length which can provide in contrast to radomes with rear surfaces that step backward or forward at different positions substantial cost benefits in fabrication/manufacturing.

It will be understood that the terminology used herein is for the purpose of describing particular aspects only and is not intended to be limiting of the disclosure. As used herein, the singular forms “a”, “an” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms “comprise” and “include” (and variants thereof), when used in this specification, specify the presence of stated operations, elements, and/or components, but do not preclude the presence or addition of one or more other operations, elements, components, and/or groups thereof. As used herein, the term “and/or” includes any and all combinations of one or more of the associated listed items. Like reference numbers signify like elements throughout the description of the figures.

The thicknesses of elements in the drawings may be exaggerated for the sake of clarity. Further, it will be understood that when an element is referred to as being “on,” “coupled to” or “connected to” another element, the element may be formed directly on, coupled to or connected to the other element, or there may be one or more intervening elements therebetween. In contrast, terms such as “directly on,” “directly coupled to” and “directly connected to,” when used herein, indicate that no intervening elements are present. Other words used to describe the relationship between elements should be interpreted in a like fashion (i.e., “between” versus “directly between”, “attached” versus “directly attached,” “adjacent” versus “directly adjacent”, etc.).

Terms such as “top,” “bottom,” “upper,” “lower,” “above,” “below,” and the like are used herein to describe the relationship of one element, layer or region to another element, layer or region as illustrated in the figures. It will be understood that these terms are intended to encompass different orientations of the device in addition to the orientation depicted in the figures.

It will be understood that, although the terms “first,” “second,” etc. may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another. Thus, a first element could be termed a second element without departing from the teachings of the inventive concept.

It will also be appreciated that all example embodiments disclosed herein can be combined in any way.

Finally, it is to be noted that, the above-described embodiments are merely for understanding the present invention but not constitute a limit on the protection scope of the present invention. For those skilled in the art, modifications may be made on the basis of the above-described embodiments, and these modifications do not depart from the protection scope of the present invention.

That which is claimed:

1. An antenna assembly for base station antennas, where the antenna assembly comprises a reflector which has a longitudinal extent, a front side and a rear side opposite the front side, wherein, the reflector has a first longitudinal section residing in a first plane and a second longitudinal section residing in a second plane that is adjacent to the first longitudinal section, where the first plane is rearward of the second plane, wherein at least part of the first longitudinal section is longitudinally spaced apart from the second longitudinal section, and wherein the antenna assembly further comprises a first column of radiating elements mounted to extend forwardly of the first and second longitudinal sections and a second column of radiating elements mounted to extend forwardly of the first and second longitudinal sections at a position laterally spaced apart from the first column of radiating elements,

wherein the first longitudinal section is a longitudinal end section of the reflector that extends to a top end of the reflector and that extends for a longitudinal extent that is less than a longitudinal extent of the second longitudinal section.

2. The antenna assembly for base station antennas according to claim **1**, wherein the first longitudinal section transitions to the second longitudinal section through a step segment that extends only in a straight lateral direction, in a plane that is orthogonal to and extending in a front to back direction between a primary surface of the first longitudinal section and a primary surface of the second longitudinal section.

3. An antenna assembly for base station antennas, where the antenna assembly comprises a reflector which has a longitudinal extent, a front side and a rear side opposite the front side, wherein, the reflector has a first longitudinal section residing in a first plane and a second longitudinal section residing in a second plane that is adjacent to the first longitudinal section, where the first plane is rearward of the second plane, wherein the antenna assembly further comprises a first column of radiating elements mounted to extend forwardly of the first and second longitudinal sections and a second column of radiating elements mounted to extend forwardly of the first and second longitudinal sections at a position laterally spaced apart from the first column of radiating elements, and

wherein the first longitudinal section has a window extending between laterally spaced apart first and second edge slats that reside on opposing longitudinally extending sides of the window.

4. The antenna assembly for base station antennas according to claim **3**, wherein the window extends only along a longitudinal extent of the first longitudinal section.

5. The antenna assembly for base station antennas according to claim **3**, wherein the window extends along a major portion of a length of the first longitudinal section.

6. The antenna assembly for base station antennas according to claim **3**, wherein the window extends laterally over at least a major portion of a width of the first longitudinal section.

7. The antenna assembly for base station antennas according to claim **3**, wherein some of the radiating elements of the first column of radiating elements extend forwardly of the first edge slat and some of the radiating elements of the second column of radiating elements extend forwardly of the second edge slat.

8. The antenna assembly for base station antennas according to claim **3**, further comprising a housing enclosing the reflector and a dielectric layer inside the housing and extending across at least a portion of the window.

9. The antenna assembly for base station antennas according to claim **8**, further comprising one or a plurality of dielectric supporting elements fixed to at least one of the first and second edge slats and supporting the dielectric layer.

10. An antenna assembly for base station antennas, where the antenna assembly comprises a reflector which has a longitudinal extent, a front side and a rear side opposite the front side, wherein, the reflector has a first longitudinal section residing in a first plane and a second longitudinal section residing in a second plane that is adjacent to the first longitudinal section, where the first plane is rearward of the second plane, wherein at least part of the first longitudinal section is longitudinally spaced apart from the second longitudinal section, and wherein the antenna assembly further comprises a first column of radiating elements mounted to extend forwardly of the first and second longitudinal sections and a second column of radiating elements mounted to extend forwardly of the first and second longitudinal sections at a position laterally spaced apart from the first column of radiating elements,

wherein the reflector has a third longitudinal section, wherein the third longitudinal section is co-planar with the second longitudinal section, wherein the first longitudinal section resides between the second and third longitudinal sections, and wherein the antenna assembly further comprises a radio frequency (RF) port, and wherein each of the radiating elements of the first column of radiating elements are coupled to the RF port.

11. The antenna assembly for base station antennas according to claim **10**, wherein a first step segment resides between the first and second longitudinal sections and electrically connects the first and second longitudinal sections and a second step segment resides between the first and third longitudinal segments and electrically connects the first and third longitudinal sections.

12. The antenna assembly for base station antennas according to claim **1**, wherein the first and second longitudinal sections of the reflector extend parallel to each other.

13. A base station antenna arrangement, comprising:

an antenna assembly where the antenna assembly comprises a reflector which has a longitudinal extent, a front side and a rear side opposite the front side, wherein, the reflector has a first longitudinal section residing in a first plane and a second longitudinal section residing in a second plane that is adjacent to the first longitudinal section, where the first plane is rearward of the second plane, wherein at least part of the first longitudinal section is longitudinally spaced apart from the second longitudinal section, and wherein the antenna assembly further comprises a first column of radiating elements mounted to extend forwardly of the first and second longitudinal sections and a second column of radiating elements mounted to extend forwardly of the first and second longitudinal sections at a position laterally spaced apart from the first column of radiating elements;

a housing with and the antenna assembly of accommodated in the housing, wherein the housing has a front side associated with the front side of the reflector and a rear side opposite the front side; and

an active antenna module which is mounted on the rear side of the housing behind the first longitudinal section of the reflector,

wherein the active antenna module comprises radio circuitry, an active reflector, and a mMIMO antenna array projecting forwardly from the active reflector.

14. The base station antenna arrangement according to claim **13**, wherein the active reflector of the active antenna module is capacitively and/or galvanically coupled to the first longitudinal section of the reflector of the antenna assembly, such that the active reflector of the active antenna module and the reflector of the antenna assembly have a common radio frequency path.

15. A base station antenna arrangement comprising:

a base station antenna comprising a passive reflector having a first longitudinal section residing in a first plane and a second longitudinal section residing in a second plane, wherein the first plane is offset from the second plane in a rearward direction, wherein the offset is a distance in a range of 0.25 inches and 5 inches; and

an active antenna module comprising an active reflector coupled to the base station antenna behind the first longitudinal section of the passive reflector.

16. The base station antenna arrangement of claim **15**, wherein the active reflector is electrically coupled to the passive reflector through at least one radome.

17. A base station antenna arrangement comprising:

a base station antenna comprising a passive reflector having a first longitudinal section residing in a first plane and a second longitudinal section residing in a second plane, wherein the first plane is offset from the second plane in a rearward direction, and wherein the offset is a distance in a range of 0.25 inches and 5 inches;

an active antenna module comprising an active reflector coupled to the base station antenna behind the first longitudinal section of the passive reflector; and

a first column of radiating elements mounted to extend forwardly of a first side of the first longitudinal section and a second column of radiating elements mounted to extend forwardly of a second side of the first longitudinal section, wherein a medial segment of the first longitudinal section is free of radiating elements, and wherein the active antenna module comprises an array of radiating elements that project forwardly behind the medial segment of the first longitudinal section or that extend forwardly into a window in the medial segment of the first longitudinal section.

18. A base station antenna comprising:

an antenna assembly where the antenna assembly comprises a reflector which has a longitudinal extent, a front side and a rear side opposite the front side, wherein, the reflector has a first longitudinal section residing in a first plane and a second longitudinal section residing in a second plane that is adjacent to the first longitudinal section, where the first plane is rearward of the second plane, wherein at least part of the first longitudinal section is longitudinally spaced apart from the second longitudinal section, and wherein the antenna assembly further comprises a first column of radiating elements mounted to extend forwardly of the first and second longitudinal sections and a second column of radiating elements mounted to extend forwardly of the first and second longitudinal sections at a position laterally spaced apart from the first column of radiating elements; and

a housing comprising the antenna assembly accommodated in the housing, wherein the housing has a front side associated with the front side of the reflector and a rear side opposite the front side,

wherein the base station antenna comprises an active antenna module which is mounted on the rear side of the housing behind the first longitudinal section of the reflector, and

wherein the antenna assembly further comprises a frequency selective surface that extends across and along at least part of the first longitudinal section of the reflector.

19. The base station antenna arrangement of claim **15**, wherein the first longitudinal section of the passive reflector comprises a frequency selective surface and/or substrate that extends laterally across and along at least part of the first longitudinal section.

20. An antenna assembly for base station antennas, where the antenna assembly comprises:

a reflector which has a longitudinal extent, a front side and a rear side opposite the front side, where the front side is configured for radiating elements to be arranged thereon, wherein, the reflector has a first longitudinal section residing in a first plane and a second longitudinal section residing in a second plane that is adjacent the first longitudinal section, where the first plane is rearward of the second plane, where the first longitudinal section is electrically coupled to the second longitudinal section and the first plane is parallel to the second plane; and

an array of radiating elements mounted to extend forwardly from the reflector, where some of the radiating elements extend forwardly from the first longitudinal section and at least one of the radiating elements extends forwardly from the second longitudinal section,

wherein the first longitudinal section of the reflector comprises a frequency selective surface and/or substrate extends laterally across and along at least part of the first longitudinal section.

21. The base station antenna of claim **20**, further comprising an active antenna module comprising an active reflector positioned behind the first longitudinal section of the passive reflector.

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